MINISTRY OF HOUSING AND
LOCAL GOVERNMENT

Technical Committee on Storm Overflows and the Disposal of Storm Sewage

Interim Report

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The Technical Committee on Storm Overflows and the Disposal of Storm Water was appointed by the Minister of Housing and Local Government on 20th May, 1955, with the following terms of reference:

> "To study and report upon practice relating to storm overflows on sewers and the disposal of storm water and to make recommendations".

For the reasons explained in paragraph 2 we asked at the time our interim report was submitted that our terms of reference should be changed to read as follows:

> "To study and report upon practice relating to storm overflows on sewers and the disposal of storm sewage and to make recommendations".

Membership of the Committee from its inception has been as follows:

H. W. Coales, Esq., C.B.E., M.C., M.I.C.E., (Chairman to December, 1956).
G. S. Wells, Esq., C.B.E., M.C., M.I.C.E., (Chairman from January, 1957, deceased May, 1962).
R. A. Elliott, Esq., B.Sc., M.I.C.E., (Chairman from May, 1962).
P. Ackers, Esq., M.Sc.(Eng.), A.M.I.C.E., (from April, 1960).
F. H. Allen, Esq., M.A., M.A.I., M.I.C.E., (to March, 1960).
F. W. Allen, Esq., F.R.I.C., F.I.S.P.
J. B. Bennett, Esq., M.I.C.E., M.I.Mun.E.
C. D. C. Braine, Esq., B.Sc., M.I.C.E., (deceased January, 1961).
J. T. Calvert, Esq., M.A., M.I.C.E., F.R.I.C.
J. B. Dempster, Esq., B.Sc., M.I.C.E.
H. Foster, Esq., M.I.C.E., M.I.Mun.E., (to December, 1958).
A. N. Gardiner, M.I.C.E., (to July, 1956).
Dr. A. Key, C.B.E., D.Sc., Ph.D., F.I.S.P.
W. F. Lester, Esq., B.Sc., F.R.I.C., M.I.S.P.
M. Lovett, Esq., O.B.E., B.Sc., F.R.I.C., F.I.S.P.
W. H. E. Makepeace, Esq., F.I.S.P., F.I.P.H.E.
J. B. Murray, Esq., (to November, 1960).
H. R. Oakley, Esq., M.Sc.(Eng.), M.I.C.E., (from June, 1961).
F. T. K. Pentelow, Esq., M.A.
A. E. J. Pettet, Esq., M.A., F.I.S.P.
H. A. Sneezum, Esq., A.M.I.C.E., M.I.Mun.E.

Secretaries:

C. J. Pearce, (to October, 1955).
H. R. Pollitzer, (from July, 1956, to October, 1958, and from June, 1960 to March, 1962).
H. A. M. Cruickshank, (from December, 1958 to April, 1960).
G. H. Chipperfield, (from May, 1962, to August, 1962).
P. McQuail, (from August, 1962).

Technical Secretaries:

J. W. M. Hawksworth, M.I.C.E., F.G.S., (to April, 1960).
M. W. Summers, M.I.C.E., M.I.W.E., M.I.S.P., (from June, 1960).

INTERIM REPORT OF THE TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE

To the Right Honourable Sir Keith Joseph, Bt., M.P.,
Minister of Housing and Local Government.

Sir,

1. We have the honour to submit to you our interim report. We have met as a full Committee on twenty-six occasions since our first meeting in May, 1955, and there have been other meetings by a Sub-Committee and many informal discussions between members.

2. In the context of our study we consider that it is misleading to speak of storm water when what is meant is a mixture of sewage and surface water. We prefer the term "storm sewage" for this mixture and have used it throughout this interim report. We thought it desirable that our terms of reference should be amended accordingly. We have used the expression "surface water" for cases where no sewage is present.

3. Where there are separate sewers for foul sewage and surface water the contents of the latter should be truly surface water. For the purposes of this interim report we have assumed that its discharge to streams or rivers should not give rise to nuisance.

4. Where the same sewers receive both foul sewage and surface water (the combined system of sewerage) their contents must always include a proportion of foul sewage even during the heaviest storm and untreated discharges from them must result in some degree of pollution, however small. Nevertheless, discharges of untreated storm sewage have always been provided for, because the flow in combined sewers during storms may reach as much as 100 times the flow in dry weather and it would be extremely costly to construct the whole of a sewerage system of sufficient capacity to accommodate such flows and to provide sewage treatment works to cope with them.

5. There are sewerage systems, known as partially separate systems, with intermediate degrees of mixing of foul sewage and surface water. In these the quantity of surface water present with the foul sewage is less than in a combined system, but generally the points made in the preceding paragraph apply to such systems, including provision for the discharge of untreated storm sewage.

6. In recent years the separate system has been adopted for many new schemes of sewerage, the sewers being designed to carry foul sewage only, all surface water being carried in surface water sewers, thus avoiding the need to discharge storm sewage to a stream. There is little doubt that in many instances where the combined system of sewerage is already long-established the conversion to the separate system would be prohibitively costly unless, indeed, it proves possible to carry out conversions in slow stages as and when large scale redevelopment is undertaken. We are of the opinion that irrespective of the relative merits of combined and separate sewerage it would be economically impracticable to contemplate a general recommendation that the discharge of storm sewage should be totally discontinued. We accordingly acknowledge that the practice of overflowing storm sewage to rivers and streams must continue to be accepted. The extent to which these discharges should be permitted must depend upon the degree of dilution afforded by the natural flow in the stream, its "self-purifying" characteristics below the point of discharge and the uses to which it may be put. There may be some

sections of rivers and streams to which the discharge of storm sewage should be prohibited, hut there will be others which are capable of receiving intermittent discharges without suffering significant harm.

7. It has heen common practice since the turn of the century to arrange for the direct discharge to rivers of all flows in excess of six times the "dry weather flow", so that the capacity of the sewers to the purification works, and the treatment capacity provided there, have been such as to cope with the "dry weather flow" of foul sewage plus five times its volume of surface water.

8. The fact that this practice has been followed for over 60 years must not be taken to mean that there has heen no change in conditions during that time. Water consumption, and therefore the dry weather flow, has considerably increased and the value of six time the dry weather flow (6 x D.W.F.) now includes a much greater quantity of surface water than it used to, so that the pollution discharged above 6 x D.W.F. should now on this account he smaller than before. On the other hand when (as is sometimes the case) the overflow setting still remains at 6 times what the dry weather flow used to be, the increase in water consumption will result in the discharge of a greater volume of storm sewage. A further point is that in the days of horse-drawn traffic, surface water (which must include road washings) was much more polluting than it is now.

9. In these days when great efforts are heing made to reduce the pollution of our rivers, there is clearly a case for a thorough re-examination of existing practice relating to storm sewage disposal. For example, ought more storm sewage to he taken to the sewage purification works and given full or partial treatment and, if so, how much? To what extent should the increasing proportion of trade effluents in the sewers affect the overflow setting and how should infiltration water figure in the calculations? Should different settings be used for streams of different sizes?

10. The shedding of storm sewage from combined or partially separate sewerage systems is effected hy "storm overflows" and these are not so simple as they sound. Their main function is to relieve the sewerage system and sewage treatment works of excessive flows in wet weather. To achieve this it is necessary, not only to ensure that the flow carried forward in the foul sewer is restricted as required, hut also to provide for the free discharge of storm sewage from the overflow.

In order to minimise the undesirable effects of the direct discharge of storm sewage to watercourses, attempts have been made in recent years to prevent the discharge of the "first flush" by the provision of storage capacity, to minimise the discharge of floating and suspended solid matter hy the introduction of screens or dip plates and to design the overflow chamher with the object of retaining as much solid matter as possihle in the foul sewer.

11. Of the many different types of storm overflows in use some are known to be unsatisfactory in operation. Discharges can occur at rates of flow differing widely from those calculated as being correct under prevailing conditions. Some are not selective in retaining a high proportion of solid matter, are not self-cleansing after storms and are not readily adjustable to meet altering circumstances. We have interpreted our terms of reference as including a study of this very complicated suhject.

12. Of the sewage and surface water conveyed to the sewage treatment works it is usual to pass all flows up to 3 x D.W.F. through the main purification plant for "full" treatment. Flows in excess of this rate, and usually up to 6 x D.W.F., are diverted to storm tanks for partial treatment. The generally accepted method of operating these tanks (but not always achieved in practice) is to allow all of them to fill with storm sewage hefore any is allowed to over-

flow from them to the stream or river. When the flow subsides after the storm the contents of the tanks are returned to the works inlet for full treatment. We have assumed that our terms of reference include a study of the provision and operation of these storm tanks.

The Nature of our Investigations

13. One characteristic of storms is that they are unpredictable; no two are exactly alike in magnitude or duration. An inch of rain falling steadily over a day may not cause a certain overflow to operate, while one tenth that amount falling in ten minutes or so in the middle of the day may result in an objectionable discharge of storm sewage from the same overflow. Whereas a few samples of the effluent from a sewage disposal works can often give a reliable indication of its quality over a long period, it is quite impossible to draw any valid conclusions from a similar number of samples taken at a storm overflow. Even more important, while the quantity of effluent discharged from a treatment plant can be measured (or can be roughly computed), it is rare indeed for any measurement of overflowed storm sewage to be attempted. Moreover, at a purification works staff are available to take samples when desired, but storm overflows are not normally attended and many of them are not easily accessible. For all these reasons information available on the operation of such overflows is both sparse and unreliable.

14. We gathered together such information as could be obtained without a special investigation, and we are grateful to local authorities and others for the information they have provided and which has been of considerable value to us. It soon became quite plain that, if we were to make recommendations which were soundly based, the facts would have to be determined by special investigations, which would need to be very carefully designed and would be both laborious and time consuming.

15. We decided that a number of drainage areas, each having different characteristics, should be studied in considerable detail over a period of at least two years. The selection of sites presented some difficulties; what was required was that each drainage area should cover at least 100 acres, have no overflow upstream of the gauging point and contain no sewers which would be surcharged during the greatest storms. Automatic recorders would be necessary to measure rainfall and sewage flows, and space and facilities would be needed for automatic samplers. The site would have to be within easy reach of personnel to service this equipment and sufficiently near to a laboratory of adequate size to undertake the analysis of the many samples which would arrive at unpredictable times.

The three such areas eventually chosen were at Northampton, Brighouse and Bradford, and it was arranged with the Department of Scientific and Industrial Research that the Water Pollution Research Laboratory should carry out the experimental work at the Northampton site and examine the results from all three sites, and that the Hydraulics Research Station should assist by designing and calibrating the flumes required for gauging flows. The Department's Road Research Laboratory gave advice and assistance on the instrumentation of each site, and in each case the co-operation of the local authority was invaluable in the construction of site works, in providing information on the sewerage system and (at Brighouse and Bradford) in maintaining instruments and collecting samples; the Yorkshire Ouse River Board analysed many of the samples taken at Brighouse. The factual results have already been published for Northampton and the data from Brighouse are now being examined. The field work at Bradford is not yet complete.

16. The investigation at Northampton has provided most useful information about the quality and quantity of storm sewage in that particular system, and

the statistical treatment of the results recounted in the technical paper* referred to is most revealing. The extent to which they are representative of the generality of combined sewerage systems, or whether they can be used to calculate what would happen in areas of different rainfall and sewer gradients, is not yet known. It is hoped that the results from Bradford and Brighouse will throw light on this.

One of the most important findings at Northampton was the highly polluting nature of the storm sewage which, on average, for flows in excess of six times the average dry weather flow, contained at least as high a concentration of suspended matter as did the dry weather sewage. Also the average B.O.D. was far greater than would have been expected if the crude sewage had been merely diluted by clean surface water. The first flush of storm sewage was found to be very strong, and generally the solids content during each storm did not fall to the crude sewage value until about half an hour after the flow had first reached three times the dry weather value. These results were attributed mainly to deposition of solids—particularly in the unusually large sewers at the head of the system—and to the subsequent scouring of deposits when the flow was augmented by surface water.

17. The use and operation of storm tanks at a sewage purification works has not been quite so complicated a matter to study, but no investigation lasting less than a year or so could be expected to yield reliable results. The information we have obtained from special investigations at Tunbridge Wells (assisted by the Kent River Board) and Stoke-on-Trent by the respective local authorities, to whom we are greatly indebted for the considerable amount of work undertaken on our behalf, will probably provide us with the basic data we need; at least we do not think that we could justify more detailed and comprehensive research at the present time. Detailed study of the information obtained is still in progress and it is also hoped to link it with any from Northampton, Bradford and Brighouse which also gives figures for flows between 3 and 6 times dry weather flow or any other range of flows which might be chosen as requiring partial treatment. Consequently our conclusions on this matter are still tentative.

18. We have also been studying different types of overflow and have subjected the characteristics of some of them to detailed mathematical examination. We have received information from River Boards about their experiences of storm sewage pollution and we are considering the effect of periodic storm sewage discharges upon streams. But until we go more thoroughly into costs we shall not be able to arrive at a policy which is economically sound. It is plain that any general increase in the amount of storm sewage taken to the sewage treatment works for treatment will be quite costly and we shall therefore attempt to weigh probable advantages against probable costs before presenting our final report.

19. Our studies are far from complete. On some matters we are therefore as yet unable to reach an informed judgment and these it would not be profitable to discuss here. On other matters the situation is becoming plain and we can give provisional conclusions. It seems right that we should do so, because the full implementation of any policy on storm sewage which involves a radical departure from the existing state of affairs will no doubt take many years, and it should be useful to those whose task it is to look ahead to know something of what our final report will recommend. Nevertheless, we must make it plain that many of our views expressed are only provisional and should the further information we are expecting to receive invalidate them we shall have to say so in our final report.

* "Storm-Water Investigations at Northampton", by A. L. H. Gameson, M.A., and R. N. Davidson, B.Sc., J. Inst. Purif. 1963—Part 2, page 105.

The Basis of Storm Overflow Settings

20. It has been stated earlier in this interim report that the common setting for storm overflows is six times the dry weather flow (6 x D.W.F.), a formula which would have more meaning if there were general agreement on what is meant by "dry weather flow" in this connection. Unfortunately there is no such agreement. The flow in many sewers is augmented, even in dry weather, by infiltration of ground water mainly through leaking joints. Some people include the infiltration in with the dry weather flow, while some do not. Most take the dry weather flow as the average over 24 hours but a few appear to take it to mean the maximum rate during a dry day, which will be more (sometimes much more) than half as much again. Some subtract the flow of trade effluents before multiplying by six to obtain overflow settings; others do not. Some authorities have a special factor, usually less than six, applicable to trade effluent flows. In these circumstances a confirmation of existing practice—if this were what we were prepared to recommend—would be of little value without an explanation of what we understood by "dry weather flow".

21. We believe that this may be unnecessary because we have reached the conclusion that overflow settings should not be calculated simply as a multiple of dry weather flow, however defined. We see little reason why, in an area where the domestic water consumption happens to be very high, accommodation should on that account be provided for a greater volume of surface water being carried to the treatment works. Nor is there any reason why the amount of infiltration should be multiplied by six (or by any other number exceeding unity) in a calculation of an overflow setting, though it may need special consideration when it is either large in volume or subject to wide seasonal variation.

22. It seems to us to be far more rational, ignoring trade effluents, for the setting to be defined as the sum (not the product) of two terms. These should be (a) the average dry weather flow, and (b) a figure, in the same units, representing the amount of surface water to be retained in the sewer. The second of these terms will inevitably be several times the first, so that an accurate definition of dry weather flow is not of great importance. In our view, dry weather flow should include the average infiltration, but the sum of the two terms would usually be little different if it did not.

23. We are not prepared at this stage to advise as to what the figure for surface water might be, nor even how it might be calculated; this will depend upon the results of investigations still incomplete. We believe that eventually the expression "6 x D.W.F." should be abandoned. We would encourage the settings of overflows being expressed firstly as . allons per day (which must be known if anything is known) and secondly as gallons per head per day (which is easier to calculate than the multiple of the dry weather flow and avoids the uncertainties attached to that term).

24. If trade effluents are received into the sewers and the capacity for surface water is maintained at that appropriate to domestic sewage only, then overflow rates will remain unchanged, but the concentration of pollution will at all times be greater in proportion to the increase in the total pollution load carried in the sewer. This would not be satisfactory and it follows that increased provision for surface water is required.

Any increase, however, means that the overflow will not begin to operate until more surface water is in the sewer. It will therefore operate less frequently than with domestic sewage alone and when the overflow is small the total pollution discharged will be smaller. During heavier storms, on the other hand, the pollution discharged will tend to be greater when trade effluent is present, unless the quantity of surface water retained in the sewer is made to vary according to the characteristics of the storm, which would be quite im-

practicable. A halance would be maintained by ensuring as far as possihle that the aggregate pollution discharged over a range of storms is not increased, accepting that it will be smaller in some storms and greater in others. If, for example, it is assumed that the surface water allowance appropriate to the domestic load is not very different from present general practice, we estimate that the extra surface water capacity appropriate to trade effluents should he twice the average daily discharge of those effluents wben they are about as strong as domestic sewage and three times the average daily discharge when they are ahout three times as strong as domestic sewage.

25. Altbough, as stated above, we can make no recommendation at present as to the amount of surface water which should he retained in combined sewers and taken to the works for treatment, there is no reason to suppose that we shall conclude that present "standard" practice retains too much. In other words we do not intend to recommend any figure (expressed in gallons per head per day) which would correspond with less than the present practice as described in paragraph 7. Indeed, it is probable that the appropriate figure will depend upon the characteristics of tbe locality and of the receiving watercourse. We believe, however, that there are many overflows set at present at figures which are far less than six times the existing dry weather flow. Where this can he improved without laying new sewers we think that it should be done immediately; a good deal of storm sewage pollution might thus he prevented at a low cost.

The use of Sewers with Spare Capacity

26. When sewers are being laid or extended it is the practice to allow for development which might take place during the next 30 years or so. This cannot be done with any precision and no douht there will continue to be cases where sewers become quickly overloaded or remain witb spare capacity indefinitely. Nevertheless, new sewers will generally be capable of carrying all tbe sewage and trade effluents which are expected to arise in tbe foreseeable future and, if the sewers are combined or partially separate, an appropriate amount of surface water. For the first few years after they are laid they should have excess capacity over current requirements and would be able to take more surface water than would seem to be appropriate to these conditions.

27. It is our view that where it would not add significantly to the cost of operation this extra surface water should be retained in the sewer—there is no virtue in overflowing storm sewage merely in order to conform with a formula. The storm overflows should be constructed at their final setting right from the start. The only exceptions which should occur are wbere the practice would entail the premature installation of pumping plant or where (and this would be unusual) an overflow on the sewerage system is preferahle to one at the treatment works.

The Siting of Storm Overflows

28. We have not given detailed consideration to the siting of overflows. Clearly each case must be judged on its merits and we do not think that any specific rules can be laid down, hut ohviously the overflows should be into as large a volume of flowing water as possible and at a place remote from public access and view. Given a choice it should be ahove rather tban below a place where strong trade effluents are discharged to the sewer. Storm overflows should be as few in number as reasonably practicable.

29. It is the general experience that co-operation between the authorities concerned is effective and we believe that the siting of overflows rarely leads to disputes.

Storm Overflows in Relation to the Sewerage System

30. In applying the conclusions of the last few paragraphs each overflow should be considered in relation to the sewerage system as a whole. For instance, to set a given overflow at a lower level than would otherwise be required might permit an overflow on another sewer to be set at a higher level and, if the sewage in that second sewer were very strong (due for instance to certain trade effluents), it would be well worth doing. In the same way two or more overflows could be so operated as to minimise discharges at the one from which they would be the more objectionable. There is clearly a need for a survey of the possibilities before taking action anywhere.

The "First Flush" of Storm Sewage

31. It has long been known that the liquid in combined sewers is more polluting in the earlier stages of a storm than later. The reasons are firstly that surface water entering a sewer pushes along in front of it the dry weather sewage so that when the level of the liquid first reaches the overflow it is largely dry weather sewage little diluted with surface water; and secondly that the liquid in the sewer, being of greater depth and flowing at a greater speed than normal, scours away deposits which have accumulated in the preceding dry spell. The relative importance of these two causes may be expected to vary with the gradient, size and general condition of the sewers. There may also be a third cause, depending on the character of the neighbourhood—the first flush of the surface water may itself be polluting due to washings from roads and other surfaces which accumulate polluting matter in dry weather.

32. Consequently a reduction of storm sewage pollution could be effected by preventing overflows from operating at all until the first flush of strong storm sewage had already passed beyond the point of overflow. Our present view is that it is worth a good deal of effort to achieve this and we are therefore commending overflow structures designed with this object in view, such as the provision of special tanks or the construction of a tank sewer downstream of the point of overflow, with the control device at its outlet end.

Types of Overflows

33. *Low Side-Weirs.* A type of overflow in common use consists virtually of side-weirs formed along the length of the sewer by cutting away the sides of the pipe. When these weirs are below the horizontal diameter of the pipe they are known as low side-weirs; they are simple and operate with no loss of hydraulic head, but we can find nothing else in their favour. Their hydraulic behaviour is difficult to analyse mathematically and calculation, not only of the flow at which they will begin to operate, but also of the flow retained in the sewer, is liable to very wide margins of error. We think that the use of this type of overflow should be discontinued.

34. *High Side-Weirs.* In this type the overflow level is above the horizontal diameter of the pipe and preferably near soffit level. Its performance is somewhat more readily calculable and the amount passed down the sewer is not so variable as with a low side-weir. Nevertheless, the degree of control is dependent upon the length of weir which can conveniently be accommodated, and we consider that a flume or other control device should be provided at the outlet. A high side-weir retains the advantage of the low side-weir in operating without significant loss of head and is altogether preferable.

35. *Stilling Pond Overflows.* In this relatively modern development a stilling pond is incorporated in the overflow chamber with the object of reducing the amount of turbulence in the vicinity of the overflow in an effort to restrict the quantity of solid matter discharged as storm sewage. The overflow arrangement may consist of a weir or weirs at the sides or end of the chamber; alternatively siphons may be used to discharge the storm sewage.

36. *Circular Vortex Overflows*. This type of overflow consists of a circular chamber with a peripheral sewage channel surrounding a circular central weir. The sewage enters the chamber tangentially and leaves after a complete circuit. The inner wall of the sewage channel is constructed as a circular weir, the cill of which is a little below the soffit of the sewer.

The passage of the sewage along the peripheral channel, induces a transverse spiral motion to the sewage. This results in a tendency for the heavier solids to move towards the inner wall of the channel, assisted by an inward cross-fall in the channel invert, and for floating solids to move towards the outer wall. When the sewage level reaches the cill of the overflow weir floating solids are held back by a circular dip plate, the bottom of which is set at the same level as the weir cill.

There is evidence that this type of overflow can reduce the amount of solid pollution carried over the weir and we consider that further research and development should be carried out on this type of overflow.

37. *Siphon Overflows*. In this type of overflow one or more siphon pipes or channels are used to discharge the storm sewage instead of a high side-weir. The inlet to the siphons is set well above invert level and below top water level to avoid, as far as possible, the carry over of either heavy or floating solid pollution. Since the operating "head" on the siphons is considerably greater than the allowable head above a weir a very compact structure is possible, and since the upstream water level during discharge does not rise above priming level the available storage capacity of the sewer and stilling pond can be used to full advantage.

The discharge of storm sewage from a siphon overflow tends to be intermittent. This intermittent action can be modified by using several siphons, each set to prime at a different level, though this is only practicable where large flows have to be handled, otherwise the pipes become so small that the risk of blockage becomes serious.

Treatment of Storm Sewage

38. Under existing normal arrangements, all flows up to about half the maximum rate arriving at the sewage works for treatment are passed through the full treatment plant which is designed hydraulically to permit this to be done. All flows above this rate are diverted to storm tanks from which they are pumped back to the inlet of the works after the storm, or overflow direct to the river, after settlement in the tanks, during the later stages of the storm. The capacity of these tanks is usually such as to provide about 2 hours detention at maximum rates of operation.

39. We shall be unable to comment upon the adequacy of these provisions until we know more about pollution due to direct discharges of storm-sewage. Only then can we judge the relative magnitudes of pollution due to settled storm sewage discharge at the works and of that due to storm sewage discharged direct. If the latter proves to be much the greater, as present indications suggest, we may have to recommend that greater flows be taken to the works, in which case additional storm tanks might be necessary to secure adequate settlement.

40. Where the arrangements are as described in paragraph 38, however, our tentative view is that the capacity now normally provided is generally near the optimum if it is utilised properly. These storm tanks serve two main purposes; first, they provide for storage so that the discharge of storm sewage is either delayed or, in relatively short storms, prevented altogether, and secondly they effect some purification so that what is discharged is not so polluting as it would have been. A third, and probably minor function, is to

effect some mixing of the strong "first flush" with weaker sewage following down the sewer, so that the first discharge from the tanks is weaker and less polluting than the "first flush" after settlement.

41. If the "first flush" is very strong and of brief duration—this depends on the size and character of the drainage area and probably on the condition of the sewers—it may well be an overall advantage to reserve one tank to contain the first flow of storm sewage so that there is no overflow from it. The "first flush" is thus always pumped hack to the inlet of the plant for full treatment. We have not heen ahle to prove the advantage of this system of working in any particular case, hut it seems likely that it will he at a maximum where there is a short outfall sewer, where the sewers are laid at steep gradients and where the area drained is small.

42. So far as we have heen able to ascertain the two functions of storm tanks —storage for pumping hack and settlement—are of almost the same order of importance when tanks are provided on the hasis of 2 hours' retention at maximum flow into them. This, of course, may vary widely from works to works, hut it does indicate the importance of pumping the contents of the tanks back for treatment as soon as the rate of flow of incoming sewage has fallen sufficiently. In the two cases which we have examined over a period about half the total storm sewage diverted to the tanks for partial treatment eventually received full treatment. The remainder was purified to the extent of ahout 50 per cent hy settlement, so that in all only about a quarter of the pollution arriving in that storm sewage which passed into the tanks actually reached the river.

43. Our information to date does confirm that the purification effected in storm tanks is due to sedimentation. Where the "first flush" contains large quantities of suspended matter the percentage reduction is quite high and this is also reflected in the figures for B.O.D.; this information has heen obtained by comparing the first hour's flow into the storm tanks with the first hour's flow from them. To determine whether the use of storm tanks as continuous settling tanks after they are full is justified this comparison is, however, not the right one to make; for that purpose the effluent from the tanks must be compared with the influent at the same time. Then the difference normally is much smaller and our tests have shown that there are occasions—for instance when storms last from the evening to early morning— when the discharge from the tank in the early morning is stronger than the storm sewage entering at the same time. On the average, however, the results we have show clearly that the reverse is the case and that it is hetter to pass the storm sewage through the tanks than to bypass them once they are full.

44. Much no douht depends upon factors peculiar to individual cases and it seems to us that it would he worth-while to provide facilities and equipment for operating the storm tanks in a number of ways and to encourage the manager to do the necessary analyses and measurements which would enable him to select and adopt the most efficient method.

Conclnsion

45. We have discussed for some time the desirability of issuing an interim report. On the one hand our investigations are not complete and we cannot advise on all matters; all our conclusions are subject to modification. On the other hand we are well aware that schemes of sewerage and sewage disposal are continually heing executed and decisions have to be reached which cannot easily he altered for a numher of years. We have decided that it is hetter that these should he made with inadequate guidance than with none at all and we hope that to that extent this report will he of some value.

46. Our principal interim conclusions are summarized as follows: —

(a) We accept that the practice of overflowing storm sewage to watercourses must continue for a long time to come.

(b) The discharge from an overflow set at six times the average daily rate of flow of sewage can in some circumstances be much stronger than sewage diluted with the equivalent quantity of clean water.

(c) Overflow settings should not be specified as a multiple of the sewage flow but as a flow of surface water which should be retained in the foul sewer in addition to the normal sewage flow. We are not at present in a position to say what this figure should be, but we do not intend to recommend overflow settings which would be of a lower standard than "6 x D.W.F.".

When trade effluents are present, allowance should be made for an additional flow of surface water which might have regard to the strength of the trade effluent in relation to that of domestic sewage.

(d) Overflow settings should, unless there are special circumstances to the contrary, make the maximum use of available sewer capacity, and where new schemes are designed to provide for expected future development overflows should be constructed to their final settings.

(e) In some circumstances there may be scope for minimizing the aggregate effect of pollution by the provision of different settings for each of a group of overflows.

(f) In addition to the volumetric setting of overflows, we attach considerable importance to the design of overflows as a means of reducing pollution. Detailed design is likely to be controlled by local conditions, but we recommend that careful consideration should be given to the practicability of incorporating storage to contain as much as possible of the "first flush" of storm sewage, as well as to measures for minimizing the amount of floating and heavy solid pollution in the overflowed sewage. Where site conditions preclude such provisions it may well be that a higher setting of the overflow is necessary.

(g) Our investigations lead us to think that the tank capacity normally provided at sewage treatment works for the impounding and settlement of storm sewage (2 hours' retention at maximum rate of operations) is generally near the optimum, but we believe there is scope for local experiment to determine the most effective method of utilising it for this dual purpose.

(h) The collection of sufficient reliable data is an essential preliminary to the determination of overflow settings, and we therefore recommend that sewerage authorities be encouraged to review their existing arrangements for the disposal of excess storm sewage from sewers and at sewage treatment works, with a view to eliciting the following basic information: —

(a) At each storm overflow—

(i) present and estimated future average daily sewage flow,

(ii) present and estimated future population served by the sewerage system upstream of the overflow,

(iii) present and estimated future average daily trade effluent and an assessment of its strength in relation to domestic sewage,

(iv) present estimated capacity of sewer below the overflow,

(v) present overflow setting expressed in terms of

(a) gallons per day,

(b) gallons per head per day,

(vi) estimated average daily flow during driest month in water-course receiving overflowed storm sewage,

(vii) rainfall statistics over the drainage area,

(viii) estimated impermeable area concerned,

(b) at each sewage treatment works—

(i) to (iii) as above,

(iv) present estimated capacity of outfall sewer(s) at works inlet,

(v) maximum recorded rate of flow delivered to works inlet,

(vi) present rate of flow at which storm sewage is separated, expressed in terms of

(a) gallons per day,

(b) gallons per head per day,

(vii) estimated average daily flow during driest month in receiving water course,

(viii) rainfall statistics over the drainage area,

(ix) estimated impermeable area concerned.

The information listed above is, we think, the minimum upon which a preliminary assessment might be made of the efficacy of the existing storm sewage disposal arrangements.

47. We have not thought it right to be specific in suggesting answers to some of the many problems awaiting solution. Nevertheless, we hope that this interim report on our work will provide at least an indication of the direction in which our studies are leading us.

We have the honour to be,

Sir,

Your obedient Servants,

(Signed) R. A. ELLIOTT (*Chairman*)

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